SMA Bending

Report Documentation Page

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Motivation

13 different SMA beam modeling papers

Traditional 4-pt bending

- Large rotations lead to undesirable axial and shear loads

3 Pure Bending Experimental Studies:

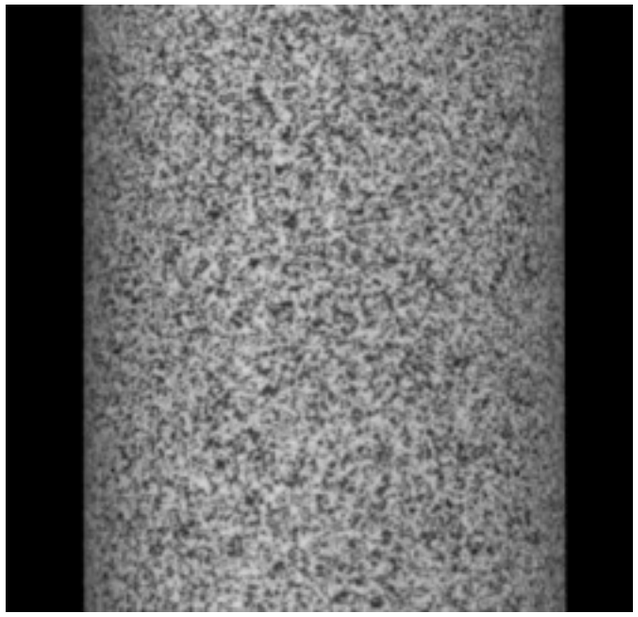
- Berg (1995)
  - Moment controlled, instead of rotation controlled
- Bundara et. al. (2000)
  - Moment controlled, instead of rotation controlled
  - Did not fully transform outer fiber of beam
  - Curvature measured from grips
- Rejzner, J., Lexcellent, C., Raniecki, B., (2002)
  - Did not fully transform outer fiber of beam
  - Curvature measured from grips

No one has characterized the same SMA in tension, compression, and pure bending

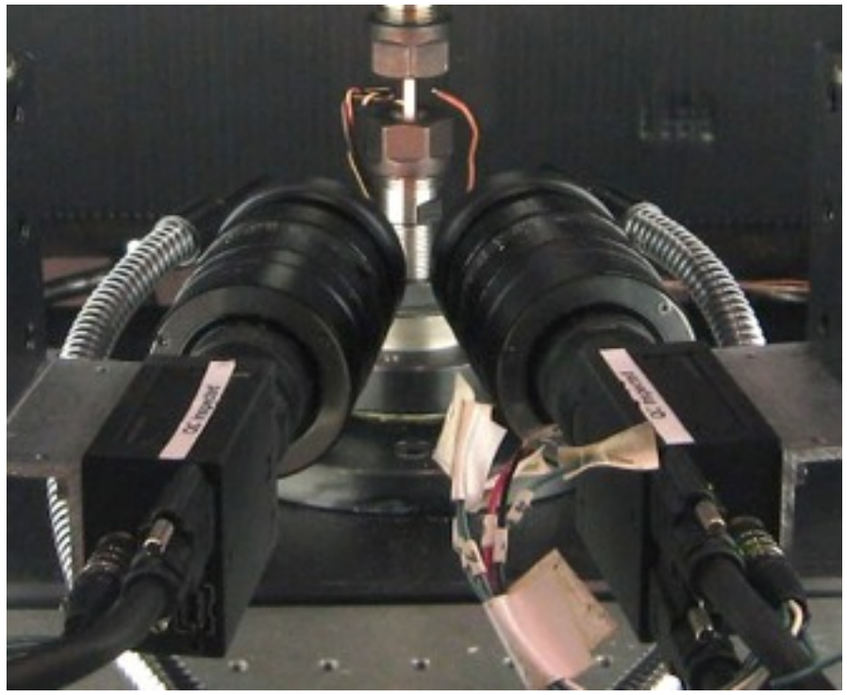
Strain is known to localize in tension. It is not known how this affects the bending behavior

Digital Image Correlation (DIC)

Apply Speckles



Capture Digital Images



Track Speckles

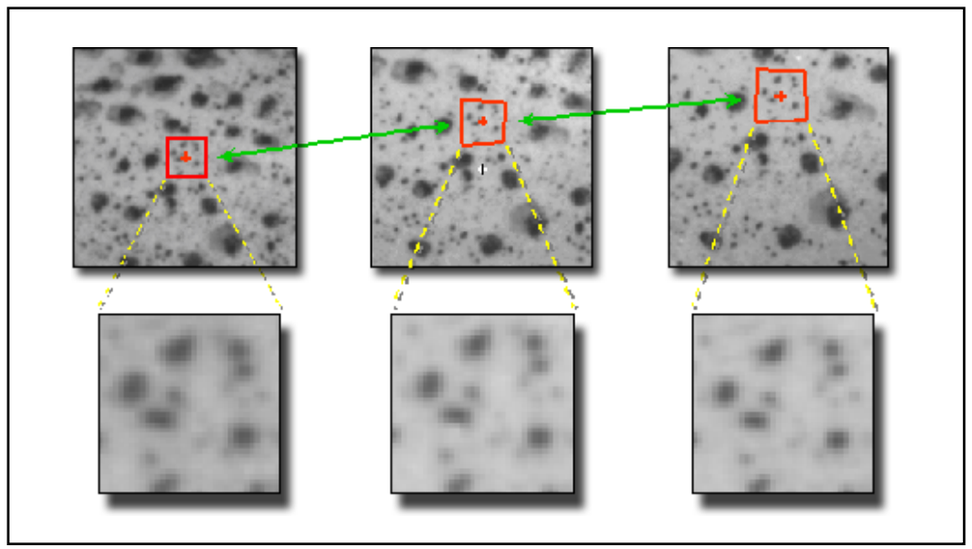


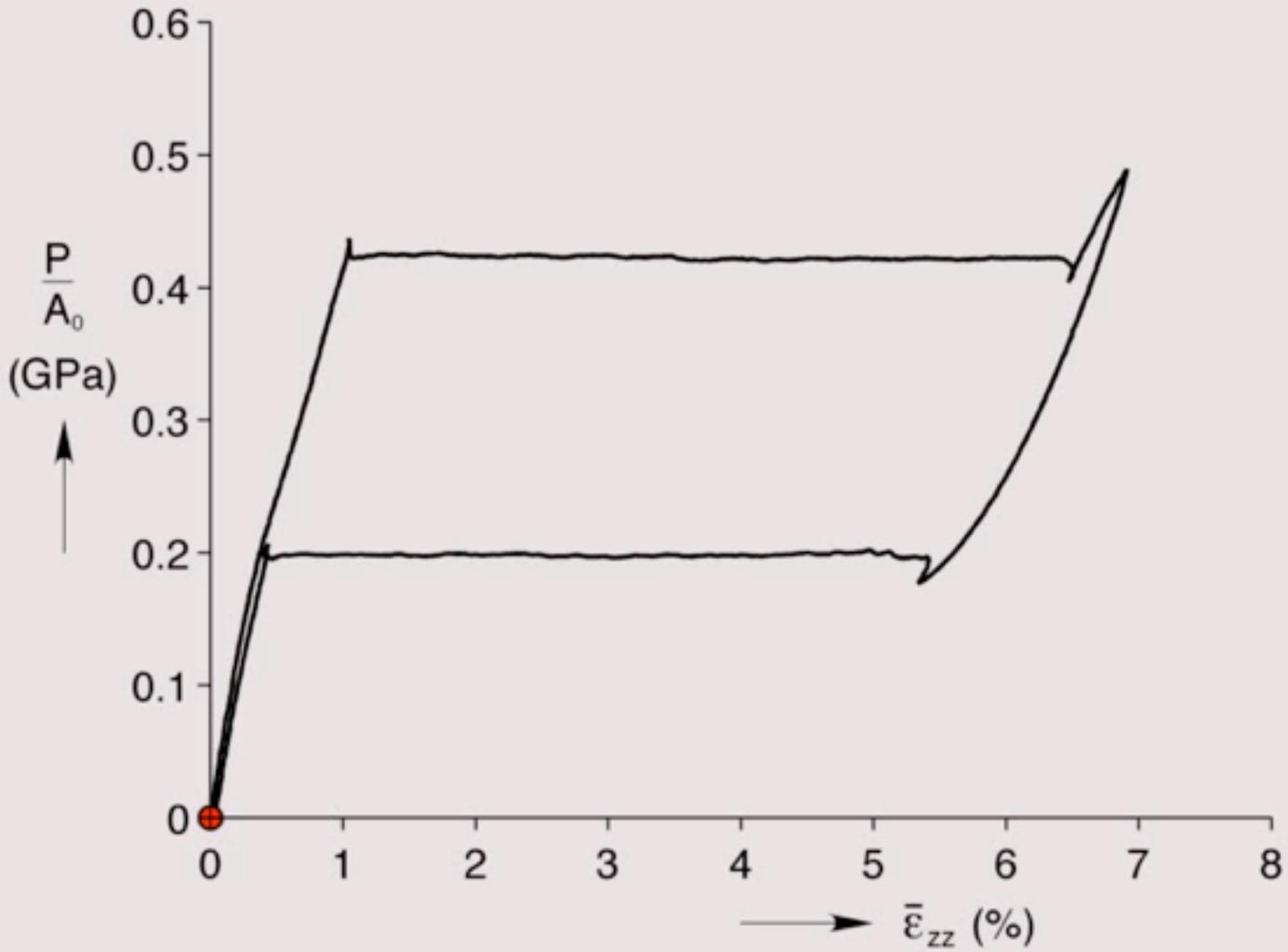
Image courtesy of Correlated Solutions, Inc.

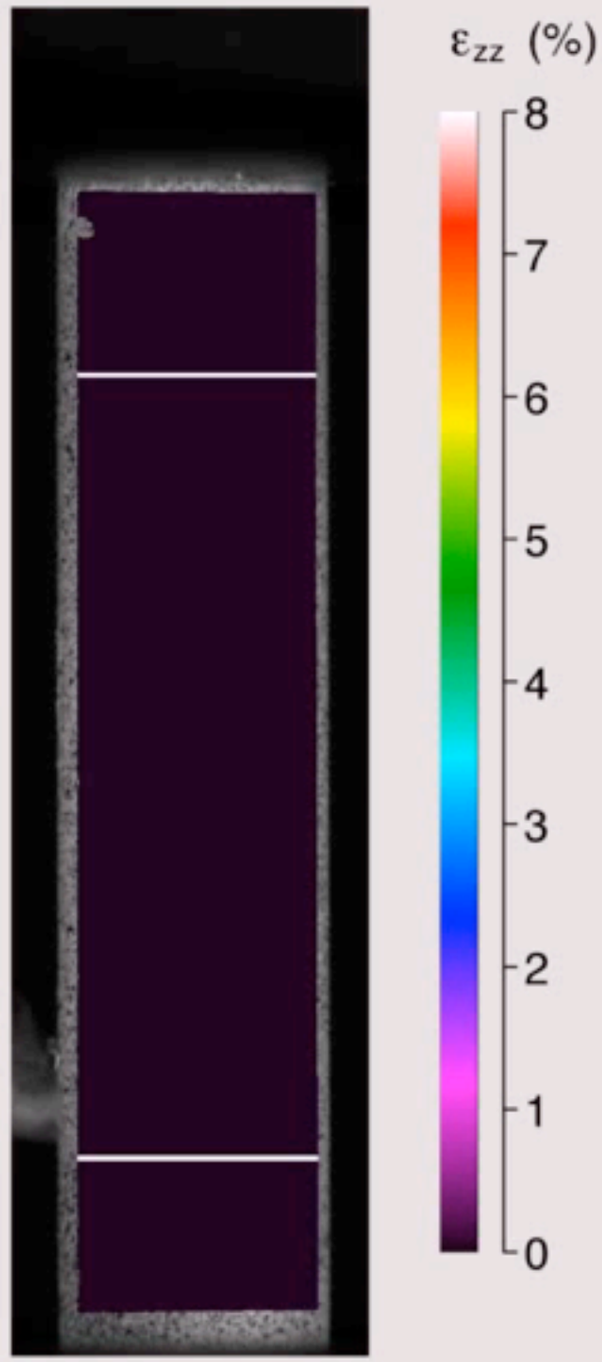
Calculate Biot Strain

$$\boldsymbol{F} = \frac{\partial \boldsymbol{x}}{\partial \boldsymbol{X}} = \boldsymbol{Q}\boldsymbol{U}$$

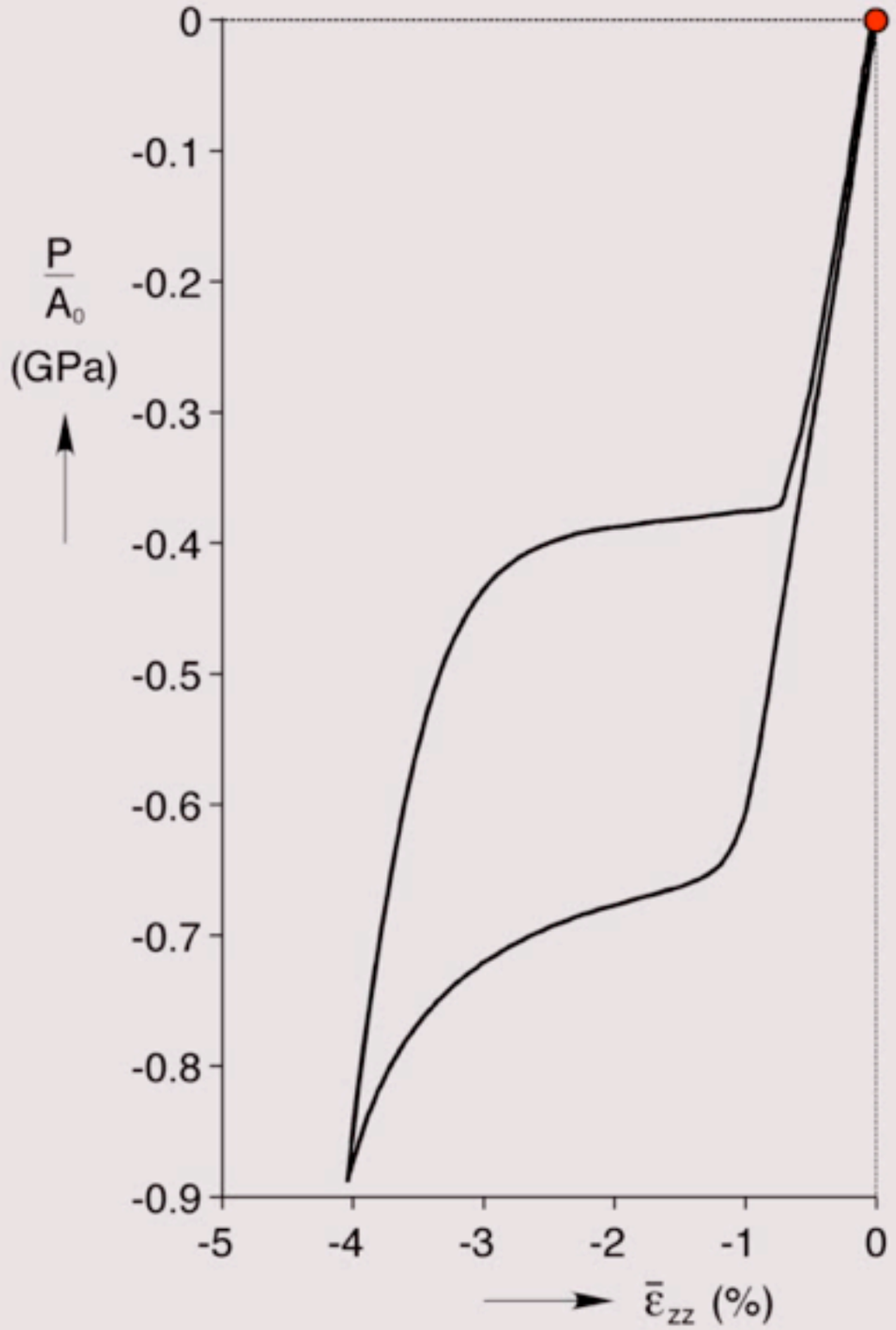
$$\boldsymbol{\varepsilon} = \boldsymbol{U} - \boldsymbol{I}$$

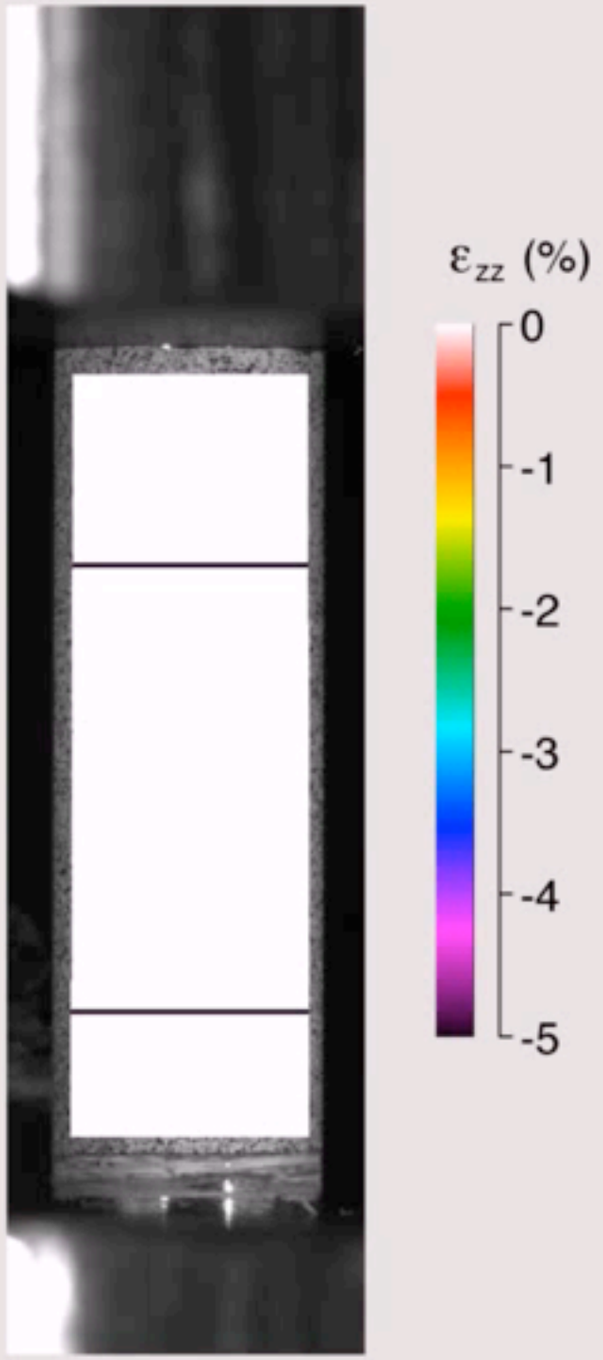
Tension Response



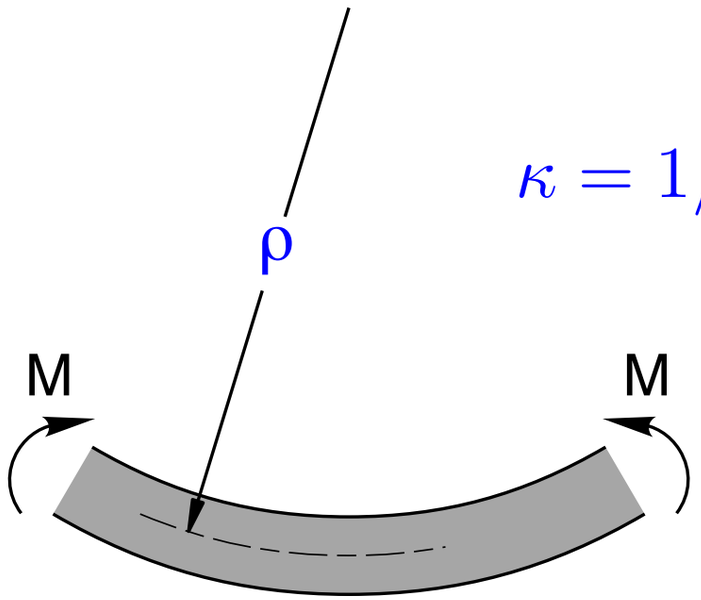


Compression Response

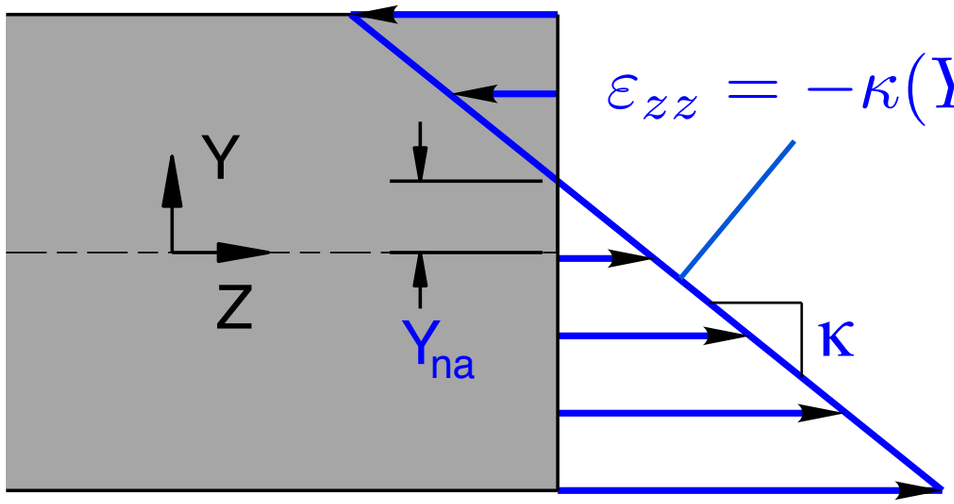




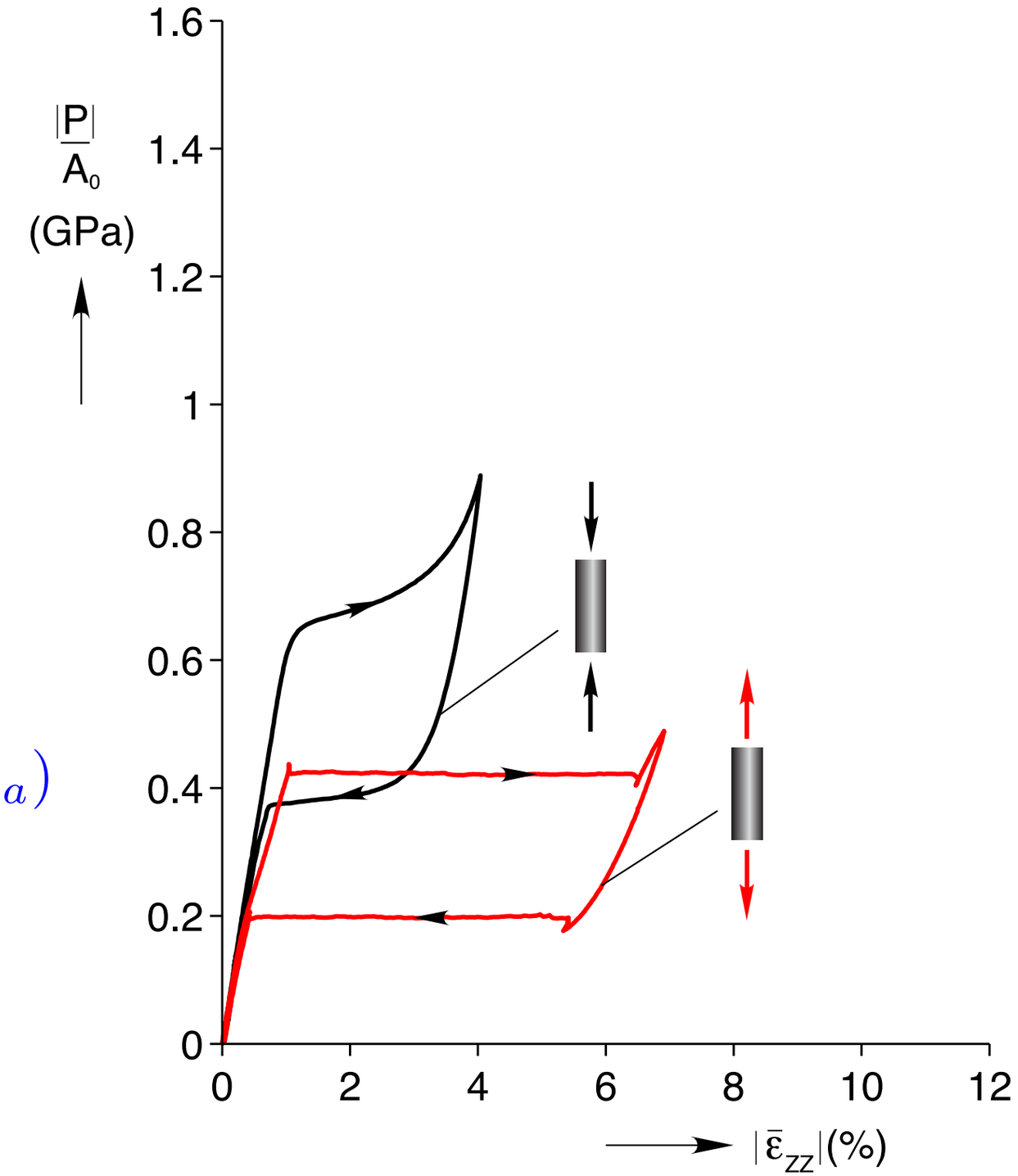
Euler Bernoulli Beam Theory



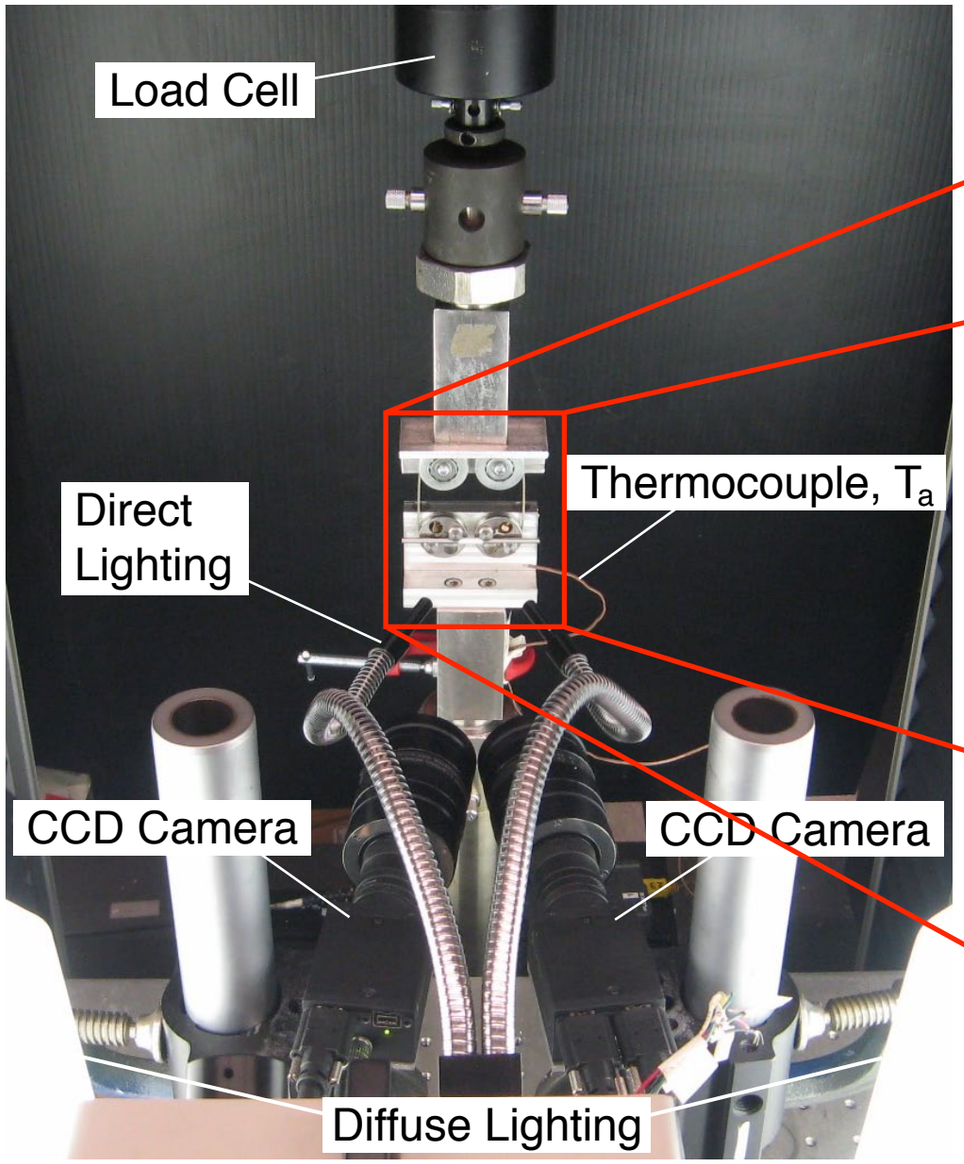
$$\kappa = 1/\rho$$

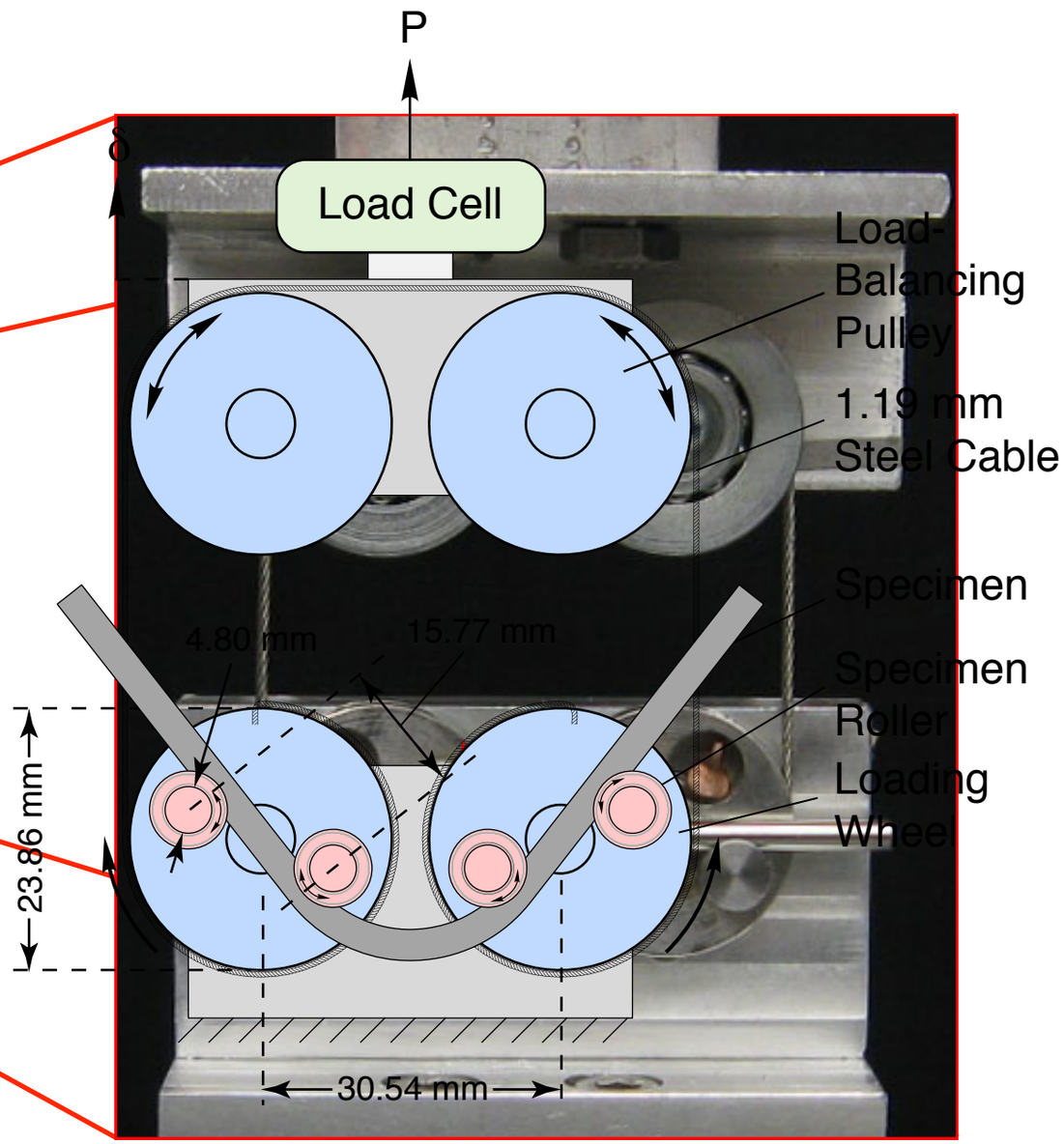


$$\varepsilon_{zz} = -\kappa(Y - Y_{na})$$

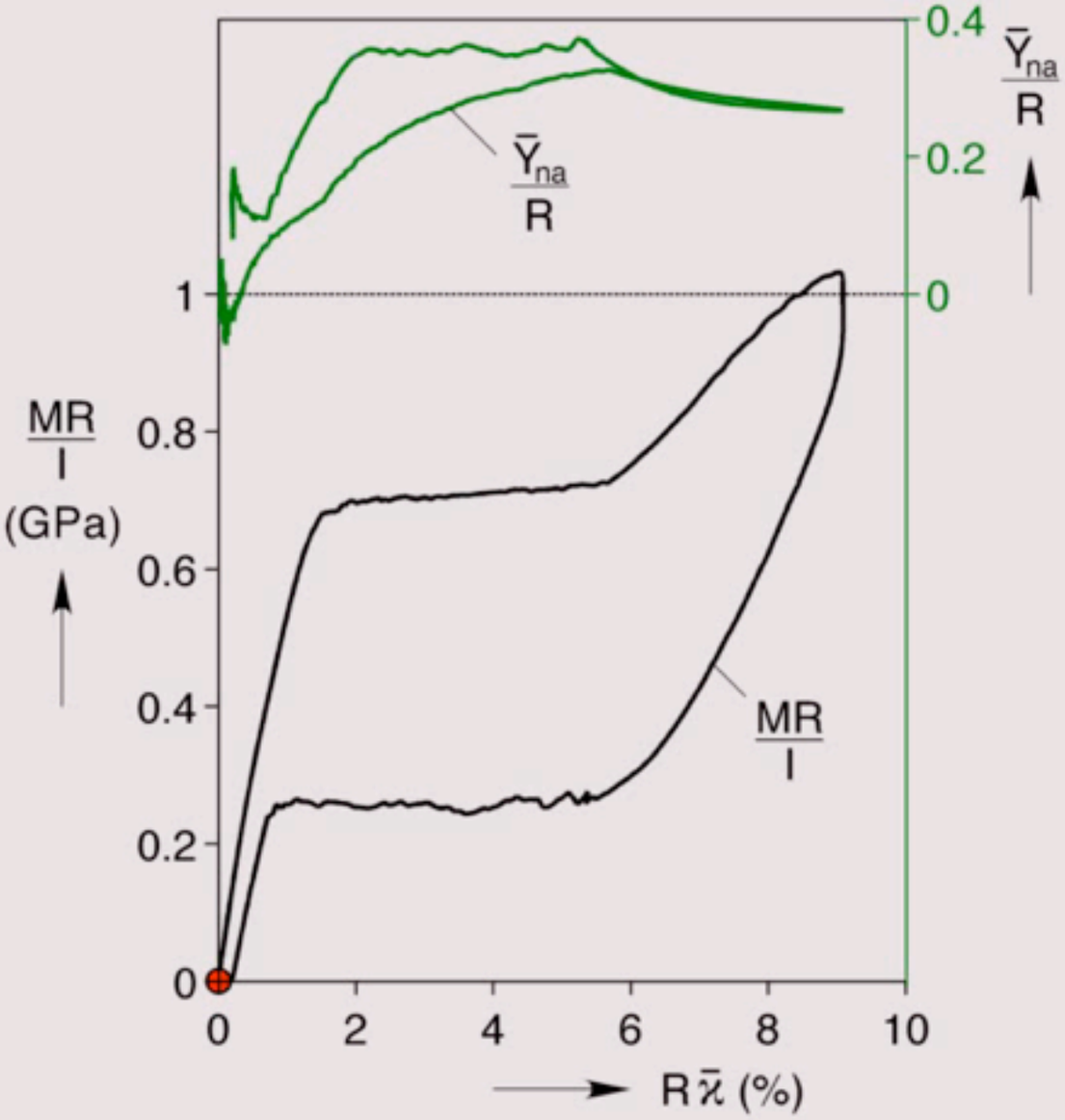


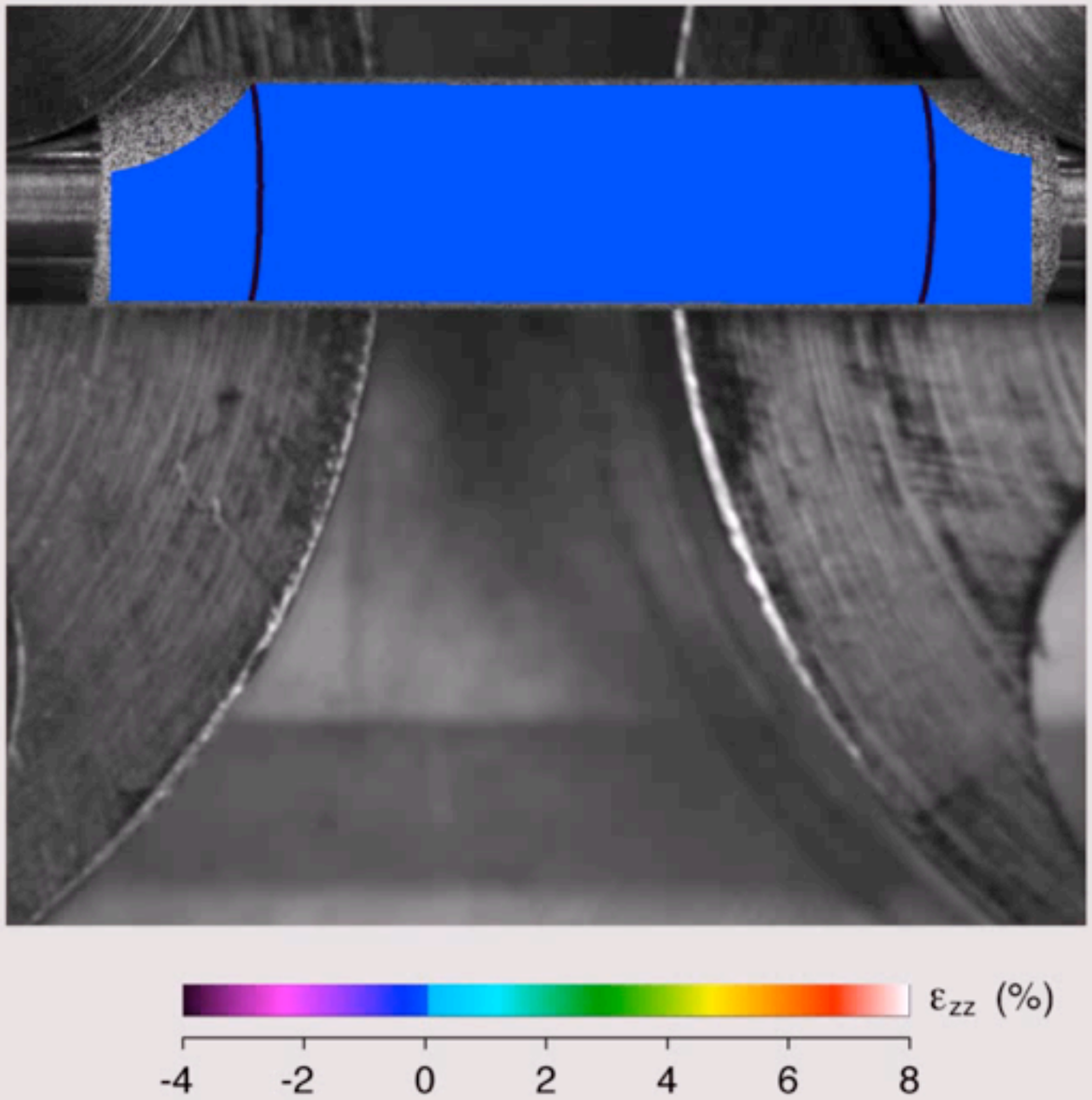
Pure Bending Setup



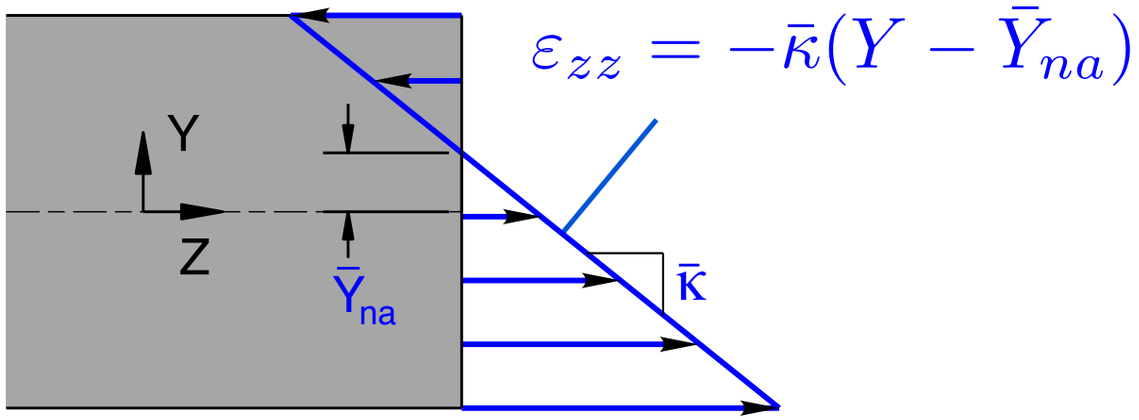


Bending Response

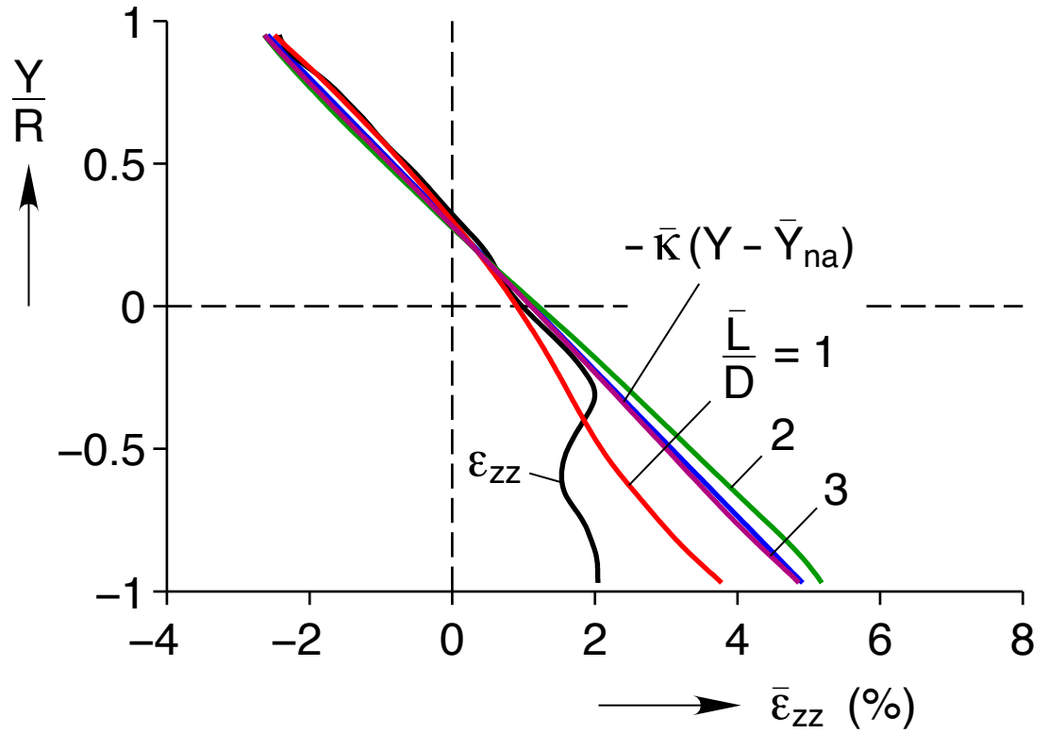


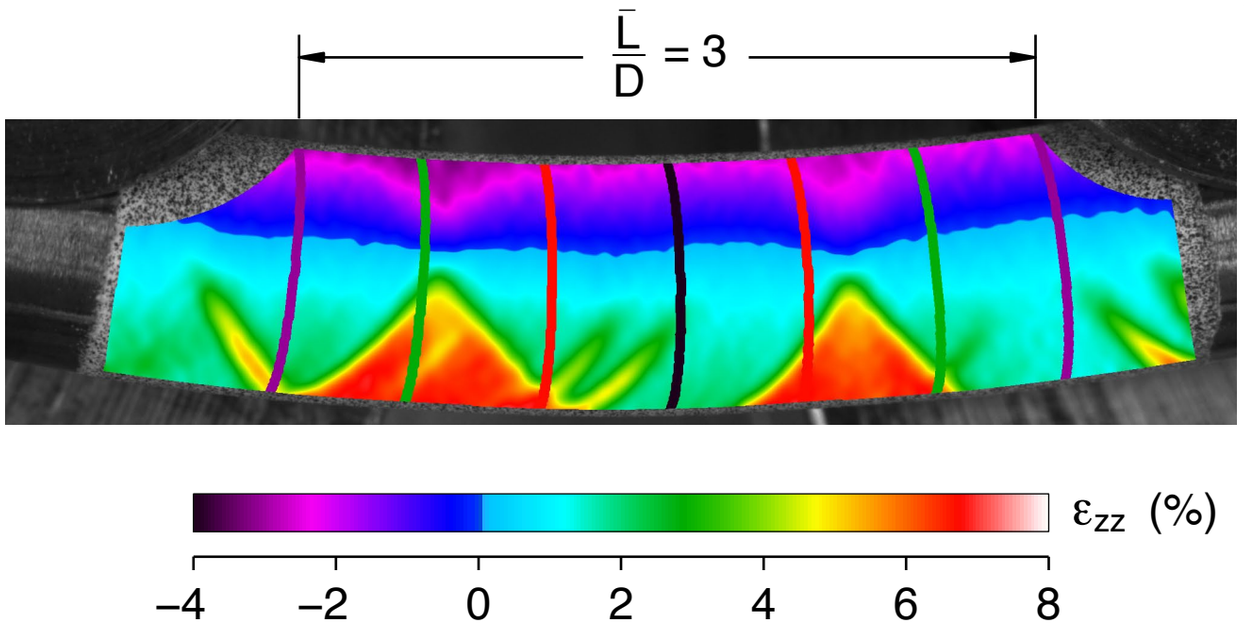


Beam Theory vs. Average Strain Profiles

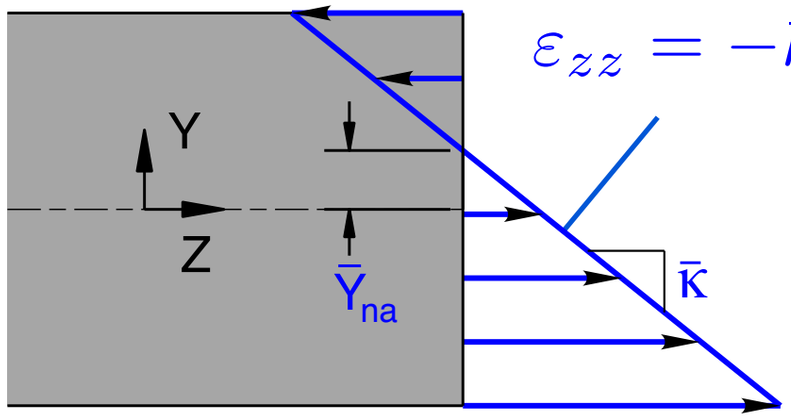


$$\varepsilon_{zz} = -\bar{\kappa}(Y - \bar{Y}_{na})$$





Beam Theory vs. Global Response



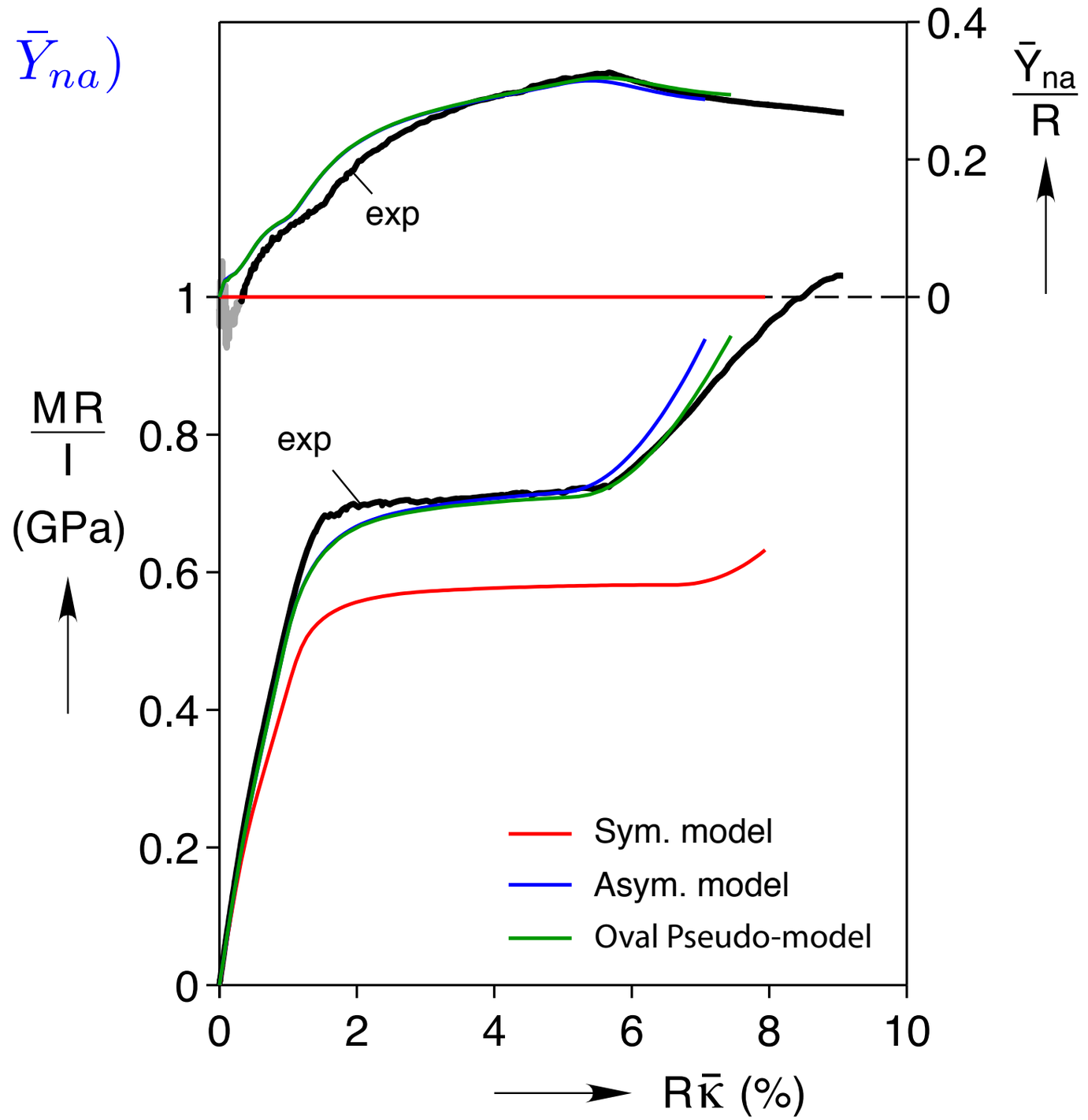
$$\varepsilon_{zz} = -\bar{\kappa}(Y - \bar{Y}_{na})$$

Locate Neutral Axis

$$P_Z = 0 = \int_{A_o} \sigma_{ZZ}\, \mathrm{d}A$$

Calculate Moment

$$M = -\int_{A_o} Y \sigma_{ZZ}\, \mathrm{d}A$$



Our Appreciation to Les Lee & AFOSR!